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Problem Chosen

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Summary Sheet

Water Scarcity? Water Scarcity!

Summary

Firstly, we establish a Comprehensive Evaluation Index System model of Carrying Capacity of Regional Water Resources. In this model, the formula of Comprehensive Evaluation Index of Carrying Capacity of Regional Water Resources (RWC) contains Regional Water Resources In Line With the Bearing Pressure Index (WCI), the Coordinated Index (CDI), the Economic Pressure Index (EPI) and the Population Pressure Index (PPI). We use these indicators to measure whether the ability of a region to provide clean water to meet the needs of its population.

Second, according to the UN water scarcity map, we pick the area of Hebei Province in China to make research. We use the model of task 1 to calculate RWC in this area. The reason of water scarcity in the area is analyzed from the lack of material and the environment in social point of view of the economy.

Third, we use the model in task 1 and use the Least Square method to predict the water resources situation and analyze it in the next 15 years in the same place.

Fourth, we use the AHP model to find out the correlation Index of the Carrying Capacity of Regional Water Resources (RWC). We design a water Intervention plans for water resources based on the task 3.

According to the Intervention plan and model, we predict the future of RWC in this area. In order to alleviate water scarcity, the policy of the government as a part of the Intervention program, which can simulate ahead, forecasting the next 15 years RWC in the same area.

Finally, we can alleviate the shortage of water resources and increase the available water resources in the people's life through the established model and the intervention plan.

Key words:

Comprehensive Evaluation Index System model of Carrying Capacity of Regional Water Resources / Carrying Capacity of Water Resources / Least Square method / AHP model / Index Variance Analysis

Contents

1. Introduction

1.1 Background

Today the world faces three major problems: population, resources and environment. The water resource is an important resource which can’t be replaced by all kinds of resources. Water resources shortage, such as being able to use clean water, and become one of the important issues of global attention[1]. According to the United Nations, 1.6 billion people (one quarter of the world's population) experience water scarcity. And water use has been growing at twice the rate of population over the last century.

Nowadays, water is a big problem in the world. If we do not take positive action, the average per capita water resources in many developing countries are becoming less and less, A few years later the global water crisis will reach its peak, According to figures released by the world conference on water resources, said after the world will be about 1.4 billion people drink less than clean water safety[1]. There will be about 1.4 billion people in the world who can't drink safe and clean water.

Water as resource, with limited circulation process of unlimited and recharge. Groundwater and surface water are continuously getting the recharge of atmospheric precipitation [2]. After the development and utilization can be restored and updated. But the water supply is different and limited. In order to be able to sustain water supply, the use of water should not exceed the amount of water supply [5]. Water is the source of life, and it is the key to the development of society and economy. If we can solve or alleviate the lack of water resources and make sure people can use clean，fresh water resources, may be it can reduce conflicts between countries or regions, the global economy would rise to a higher level.

2. Problem statement and analysis

2.1 Problem statement

The International Clean water Movement wishes our team can help them to solve the world’s water problems. We should build up a model that provides a measure of the ability of a region provide clean water to satisfied the needs of its population. In the process of our model, we should consider about the factors that affect supply and demand dynamics. And use the UN water scarcity map to select a country or region where water is either heavily or moderately overloaded. Also, explain why this region suffer water scarcity. Then, we use our model to predict water situation of this region in the next 15 years.

Later, design an Intervention plan with all factors of water scarcity. and analyze the advantages and disadvantages as a whole. How does your plan mitigate water scarcity. Explain the model, and use Intervention plans to explain water availability of a region what we select. Finally, explain the advantages and disadvantages of our model.

2.2 Overall analysis

In order to determine whether a region has the ability to provide clean water to meet the needs of its population, we use Carrying Capacity of Water Resources (CCWR) to explain and build up the Comprehensive Evaluation Index System Model of Carrying Capacity of Regional Water Resources (RWC)[6]. We put forward to the conceptual model of CCWR evaluation and use the RWC to determine the CCWR in this area, and analyze the dynamic factor by entropy weight method [14].

According to the UN water scarcity map, we pick Hebei Province in China to make research. We use the model in task 1 and obtained the data by the information [16]. Then it can figure out RWC [6].

The model in task 1 combined with the collected data six years ago, we will predict RWC in the next 15 years by the Least Square method and we can predict RWC in the next 15 years. Next, we analyze lives of citizens of this region from social and environmental drivers and water resources in Hebei Province in the next 15 years.

We adopt to the AHP model [15] to design Intervention plan, build up Recursive Hierarchy model, Judgment matrix of recursion level [15], Hierarchical single ranking and consistency check to discuss what factors affect the larger, also, On the basis of the found data, the proportion of each factor in RWC. Therefore, we can get the Intervention plans, then analyze the overall effect and the advantages and disadvantages of Intervention plans under the background and we are able to explain how to relieve water scarcity.

Form the established model and the Intervention plan what we build, we can predict water availability into the future. The results what we gain can judge whether this area can less susceptible to water scarcity and also we can judge whether water will become a critical issue in the future.

3. Basic assumption

There will be no serious climate change during the forecast period, such as successive droughts and severe natural disasters.

Changes in annual precipitation are maintained within a small range.

In a short time, the development of water resources shows the growth mode of damping factor, which can be considered as a very small change. The water resource system is not changed in a short time.

4. Glossary & Symbols

Glossary

Comprehensive Evaluation Index of Carrying Capacity of Regional Water Resources (RWC): Comprehensive evaluation and basis and standards of research, of Regional water resources, social, ecological and economic coordinated development.

the Economic Pressure Index (EPI) [6]**:** The pressure of economic development in the regional water resources. The number is greater, the pressure of economic development in the regional water resources is greater.

the Population Pressure Index (PPI) [6]**:** Population pressure what the regional water resources carrying. The number is greater, the population pressure what the regional water resources carrying is greater.

the Regional Water Resources in Line With the Bearing Pressure Index (WCI): Pressure of regional water resources, social, ecological and economic coordinated development. The number is greater, pressure of regional water resources, social, ecological and economic coordinated developments greater in the regional water resources.

the Coordination Index (CDI): The degree of regional water resources, social, ecological and carrying capacity of water resources is greater, the level of water availability is greater, otherwise, it is lower.

Symbols

table 1 Variables and their meanings

Number	Sign	Significance
1	WCI	the Regional Water Resources in Line With the Bearing Pressure Index
2	CDI	the Coordination Index
3	EPI	the Economic Pressure Index

4	PPI	the Population Pressure Index
5	CCP	Pressure Index of Water Resources System
6	CCS	Carrying Pressure Index of Water Resources System
7	F_e	Maximum Economic Scale of, Carrying Capacity of Regional Water Resources
8	GDP_e	Gross Domestic Product
9	F_p	Population of Water Resources
10	P_e	Current Population Size
11	CW	Comprehensive Evaluation Index of Carrying Capacity of Regional Water Resources
12	λ_{max}	Maximum Eigenvalue
13	CI	Coincidence Indicator
14	CR	Consistency Ratio

5. Models

5.1 Comprehensive Evaluation Index System Model of Carrying Capacity of Regional Water Resources [5]

Clean water, which means clean available water resources, we believe that the people can use the water resources.

After entering the new century, people pay more and more attention to the problem of water resources, and the global water problem also began to become increasingly serious. In order to improve the use of clean water to meet the needs of its population, we use Carrying Capacity of Water Resources (CCWR)[5] to explain and build up the Comprehensive Evaluation Index System Model of Carrying Capacity of Regional Water Resources.

5.1.1 The Selection of Comprehensive Evaluation Index[5]

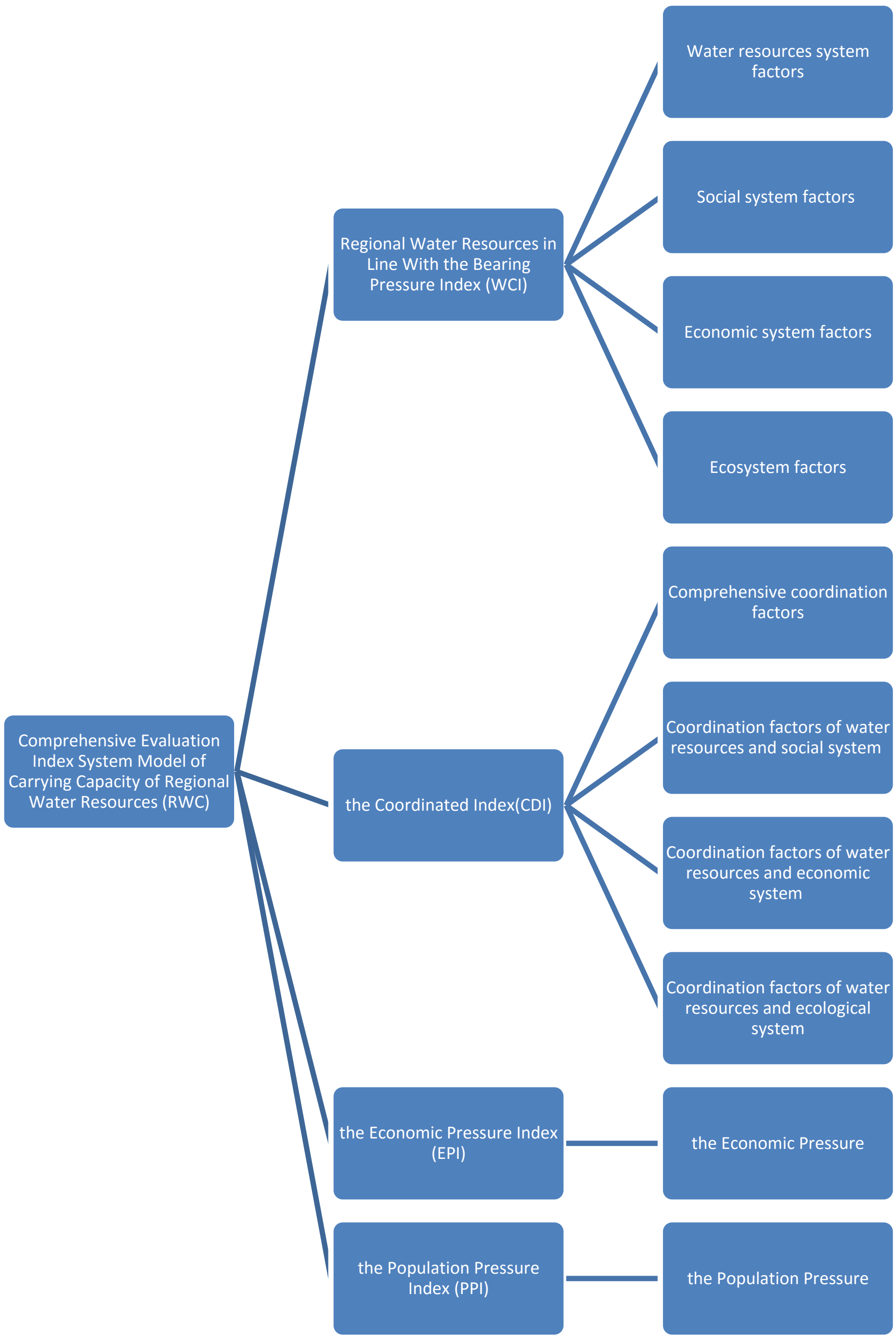
Because the carrying capacity of water resources is influenced by many factors, we adopt to compound system and search for the main index of the comprehensive index of CCWR in the area. Next, we make the main index divide the various factors. This evaluation index of the model must meet the harmonious development of China's water resources and economy, society and ecological environment, also meet the basic national policy of sustainable development in China.

From the perspective of China's economy, society, ecological environment and water resources, we should consider about comprehensive evaluation index system of carrying capacity of regional water resources. This model combines economy, society, ecological environment and water resources in four aspects, to evaluate the regional water resources carrying capacity with a system.

5.1.2 The Establishment of Comprehensive Evaluation Index[5]

5.1.2.1 Conceptual model Conceptual model of evaluation of water resources carrying capacity

Conceptual model of evaluation of water resources carrying capacity[8] (Figure 1)



5.1.2.2 Establishment of comprehensive evaluation index system

Step1：Water Resources in line with the Carrying Pressure Index

Water Resources in line with the Carrying Pressure Index formula [5] is：

$$\mathrm{WCI} = \frac{\mathrm{CCP}}{\mathrm{CCS}}$$

Inside, WCI is the regional water resources composite system carrying pressure index, CCPis the Pressure Index of Water Resources System, CCS is t Carrying Pressure Index of Water Resources System .

Step2：The Economic Pressure Index

The Economic Pressure Index formula [5] is：

$$\mathrm{EPI} = \frac{\mathrm{F_e}}{\mathrm{GDP_e}}$$

Inside, $\mathrm{F_e}$ is the Maximum Economic Scale of, Carrying Capacity of Regional Water Resources, $\mathrm{GDP_e}$ is the Gross Domestic Product.

Step3：Population Pressure Index

Population Pressure Index formula is：

$$\mathrm{PPI} = \frac{\mathrm{F_p}}{\mathrm{P_e}}$$

Inside, $\mathrm{F_p}$ is the Population of Water Resources, $\mathrm{P_e}$ is the Current Population Size.

Step4：Build up the Comprehensive Evaluation Index of Carrying Capacity of Regional Water Resources

According to the reference of all kinds of data and the model formula, build up the comprehensive evaluation index system model of carrying capacity of regional water resources, and the Comprehensive Evaluation Index of Carrying Capacity of Regional Water Resources formula [5] is:

$$\mathrm{RWC} = \sqrt[3]{\mathrm{CDI} \times \mathrm{WCI} \times (\alpha\mathrm{EPI} + \beta\mathrm{PPI})}$$

Inside, RWC is the Comprehensive Evaluation Index of Carrying Capacity of Regional Water Resources, CDI is the Coordination Index, WCI is the Water Resources in line with the Carrying Pressure Index, EPI is the Economic Pressure Index, PPI is the Population Pressure Index.

Step5：Classification of comprehensive evaluation index of carrying capacity of

regional water resources

Through the steps as well as the data, we can combine with China's national conditions and many influence factors of Chinese carrying capacity of water resources. Finally, we gain the Classification of comprehensive evaluation index of carrying capacity of regional water resources [2].

Classification of comprehensive evaluation index of carrying capacity of regional water resources

table 2

RWC	0.00-0.50	0.51-O.80	0.81-1.00	1.01-1.3	>1.3
Level	Carry abundant	Carry appropriate	Carry Basically	Moderately overloaded	Heavily overloaded
Degree	Water resources abundance	Coordinated utilization of water resources	Water resources shortage	water scarcity	Serious lack of water resources

Step6：Analysis of dynamic factors of entropy weight method[15]

Due to the carrying capacity of regional water resources has a lot of factors, which leads to each index has dynamic performance. Such as population growth, economic development, the change of the ecological environment and so on, which will affect the carrying capacity of water resources. Therefore, we use the index variation degree analysis[15], and it change these subjective dynamic factors into objective：

Calculate the i th project index in the j th index, we can gain Specific weightP_{ij}:

$$P_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}$$

Calculate Entropy e_j in the j th index：

$$e_j = -k \sum_{i=1}^{m} P_{ij} \cdot \ln P_{ij}$$

Calculate Entropy weight ω_j in the j th index：

$$\omega_j = \frac{1 - e_j}{\sum_{j=1}^{m} (1 - e_j)}$$

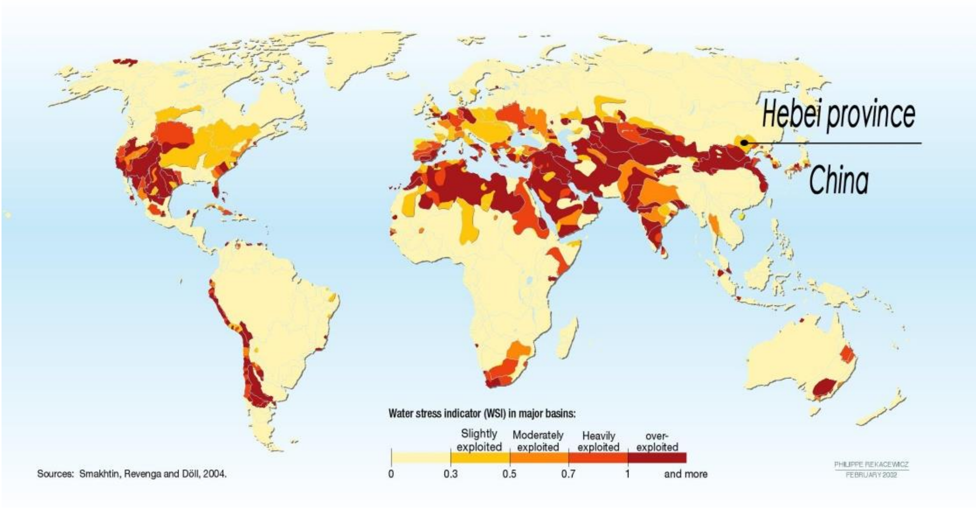
Determine the index of comprehensive weight β_j:

$$\beta_j = \frac{\alpha_i \omega_i}{\sum_{i=1}^{m} \alpha_i \omega_i}$$

Therefore, we use the index variation degree analysis, and it change these subjective dynamic factors into objective.

5.2 Analyze the Reason of Water Scarcity in some area

According to the UN water scarcity map, we choose the area of Hebei Province in China to analyze and research. The location of Hebei Province in China in the UN water scarcity map. (figure 2):



UN water scarcity map (figure 2)

According to the figure 2, Hebei Province in China belongs to the area of water resources in the UN water scarcity map. We refer to many data obtained from the data, Combining with the model in the task 1 can calculate CDI，WCI，EPI and PPI. The last calculating RWC, we can get:

$$\mathrm{CDI} = 0.18，\mathrm{WCI} = 8.37，\mathrm{EPI} = 1.192，\mathrm{PPI} = 1.5524，\mathrm{RWC} = 1.274 < 1.30$$

5.2.1 The degree of Water Scarcity

According to the model in the task 1, we can get RWC: 1.274<1.30. Indicating Hebei Province’s Water Resources Carrying Capacity is water scarcity. We define the Water Resources Carrying Capacity is basically in accordance with the UN water scarcity map, which shows our model is available and Has certain persuasive power.

5.2.2 The Reason of Water Scarcity

5.2.2.1 Physical scarcity

The influence of environmental factors

- The forest coverage rate is 23.41% in Hebei Province, China, that is less than the world's average forest coverage rate of 32%[16]. Soil erosion is serious, the quantity of water and soil is low, and the water resource is low, which leads to the shortage of water resources, because the low forest coverage rate in Hebei Province, China.

- Ecological water demand rate is low that is be a relatively difficult state.

The influence of social factors

- Rapid population growth, leading to the local water resources in Hebei Province can’t meet the needs of local people.
- The land utilization rate is too high, so that the land desertification intensifies, water resources are difficult to maintain, resulting in water resources can’t meet the local needs.

5.2.2.2 Economic scarcity

The influence of environmental factors

- The reason of Rapid economic development in Hebei Province is near the capital of Beijing. But the heavy industry in Beijing, China, moved to Hebei province that the region's environmental pollution is serious, and the water pollution is aggravated, which leads to the economic water shortage[7].

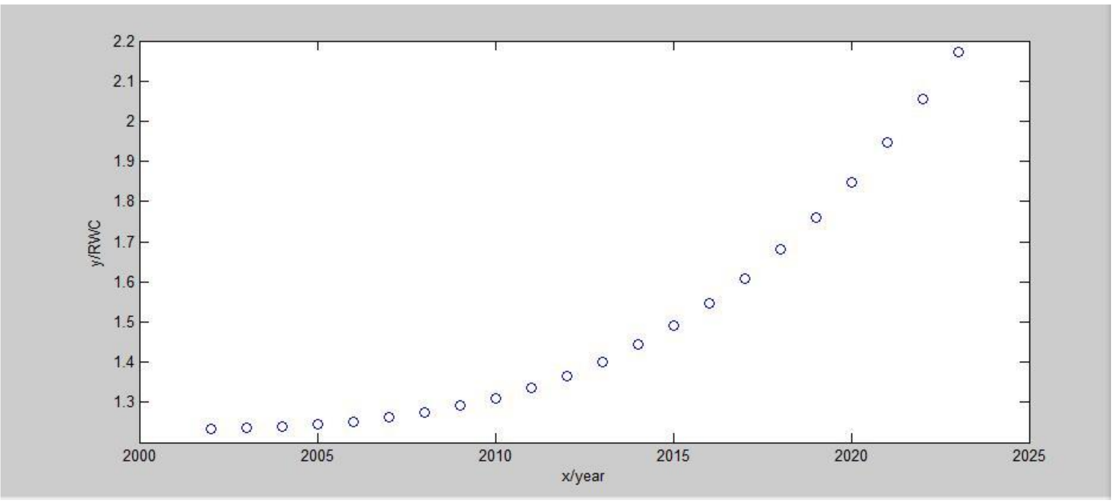
The influence of social factors

- Water resources and social coordination ability is poor, resulting in a low degree of matching of water resources and the local population.
- Industrial development will affect the industrial water consumption, industrial water consumption greatly increased, resulting in water resources can’t meet local needs.
- Groundwater pollution is serious and water quality is deteriorating, which leads to the reduction of available water resources that can’t meet the local demand[1].
- The rapid development of urban size, population growth and the continuous improvement of the people's province, but the development of the city's water supply industry is slow, the development of water resources can’t meet the needs of urban development, water supply and demand contradiction[1].

5.3 To Predict the Water Situation in 15 years and the influence of the situation

5.3.1 The Water Situation in 15 years

According to the task of a model and combined with the collected data from 2002-2008, we use the Least Squares method to predict the next 15 years of RWC [1] in this area and use the MATLAB software to get the curve. (figure 3):



RWC curve of change over time (figure 3)

We can find some rules from the figure 3: the RWC is rising and rising faster and faster in the next 15 years, showing that the lack of water resources is becoming more and more serious. Due to these riots water resource shortage may lead to ecological system disorder, cause chaos in the society, economy and ecological environment.

5.3.2 How does the situation impact the lives of citizens of this region in 15 years?

Affect people's life from the environment[12]

We can know that the future 15 years of serious deficit of water resources in Hebei Province in China. No matter in normal years and dry years are lack of water, it can only rely on overexploitation of groundwater to maintain the development of life and production. And since the 80's, groundwater exploitation in about 10 billion[16] cubic meters, an average of over 3 billion[16] cubic meters per year. The exploitation of ground water in the infinite degree makes the groundwater funnel expand and deepen year by year. But the groundwater resources are limited. Over exploitation leads to the region water resources quantity, can cause a series of geological and natural environment problems. In this way, soil erosion, frequent dust storms and other issues will seriously affect the living environment of local people.

Affect people's life from the society

We know that water resources in Hebei Province will be severely deficient in the next 15 years, and water shortage causes water there is no guarantee that the people's normal life.

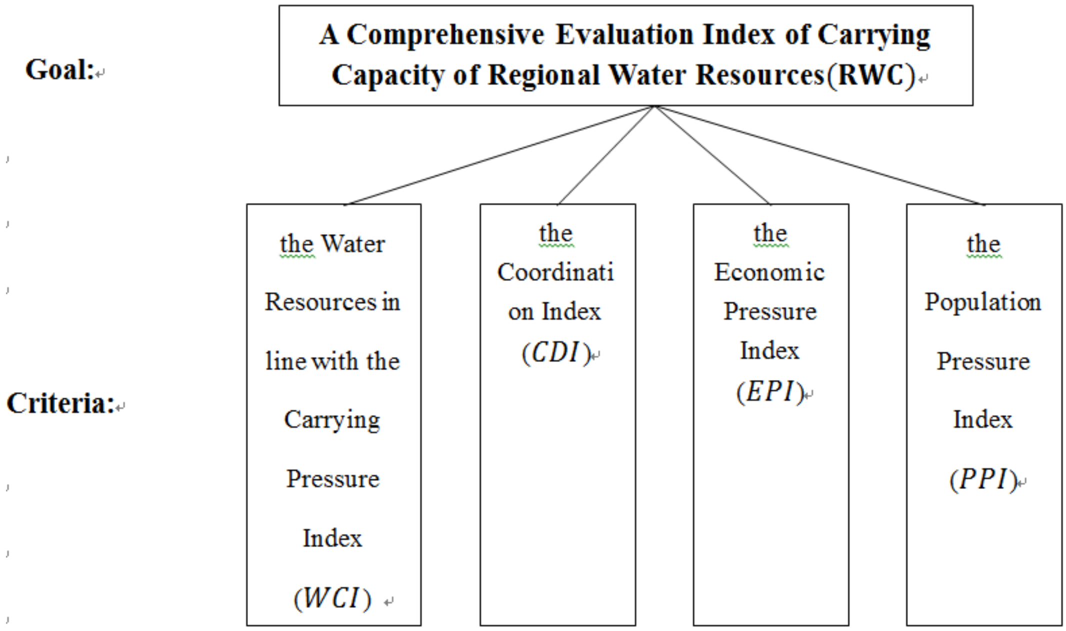
Some serious cities have to take limited or regular water supply. Water has become a major problem in these cities, but also affect the stability of social order.

5.4 Design an Intervention Plan and Discuss the Strengths and Weaknesses

5.4.1 The Establishment of Intervention Plan by the AHP[15]

Step1: The Foundation of Model

First of all, the problem is decomposed into three levels, the first layer is the goal layer (Comprehensive Evaluation Index of Carrying Capacity of Regional Water Resources).The second layer is the criterion layer: the Water Resources in line with the Carrying Pressure Index, the Coordination Index, the Economic Pressure Index, the Population Pressure Index (four criterion), The schematic can be divided into levels, eg, (figure 4):



Hierarchical analysis diagram (Figure 4)

According to the data, we can get four criterion WCI, CDI, EPI, PPI in the proportion of regional water resources in line with the bearing pressure index.

Step2: Determining the weighs:

Take two factors x_i and x_j, ues a_{ij} expressed as $x_i$and x_j for impact on Z the ratio of the size, All the comparison results with $A = (a_{ij})_{n*n}$, Said A to Z, X the paired comparison between the judgment matrix (hereinafter referred to as judgment matrix).

Easy to see, if x_i and x_j for impact on Z the ratio of the size, so x_i and x_j for impact on Z the ratio of the size is $a_{ji} = \frac{1}{a_{ij}}$[15].

Assuming $=（a_{ij}）_{n*n}$ meet:

$a_{ij} > 0$,（2）$a_{ji} = \frac{1}{a_{ij}}$（$i, j = 1,2,\cdots, n$）, therefore, we think it matrix A isPositive reciprocal matrix（$a_{ii} = 1, i = 1, \cdots, n$）.

Form a pair-wise comparison matrix A, where the number in the ith row and jth column gives the relative importance of Oi as compared with Oj.

Use a 1–9 scale, with

scale	Meaning
1	if the two objectives are equal in importance
3	if Oi is weakly more important than Oj
5	if Oi is strongly more important than Oj
7	if Oi is very strongly more important than Oj
9	if Oi is absolutely more important than Oj

Table 3[14]

From 1 to 9 scale table, through the two comparison of each factor, therefore result in the following matrix:

judgment matrix A – B (Table 4)

RWC	WCI	CDI	EPI	PPI
WCI	1	4/3	1	2
CDI	3/4	1	3/4	3/2
EPI	1	4/3	1	2
PPI	1/2	2/3	1/2	1

The table 4 is expressed as four indicators: The importance of the ratio of the Water Resources in line with the Carrying Pressure Index (RWC), the Coordination Index (CDI), the Economic Pressure Index (EPI), the Population Pressure Index (PPI).

Finally, we adopt to MATLAB to calculate Maximum Eigenvalue, Coincidence Indicator and Consistency Ratio.

Step3：Level single sorting and consistency check[14]

We adopt to MATLAB to Maximum Eigenvalueλ_{max}, $\lambda_{max} = 4$, Matrix A use denote normalization, and get the feature vectors:

$$W = (0.3077，0.2308，0.3077，0.1538)$$

Consistency check:

Compute the Consistent IndexCI

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

When $CI = 0$,A is the same array; CI is greater, The A degree of inconsistency is more serious.

Get the following data:

Judgment matrix A – B: $CI = \frac{\lambda - n}{n-1} = 0$

Find the mean random consistency index RI. Look up table, as shown in Table 5 below:

numerical value of random consistency index table RI (Table 5)

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Compute the Consistent RadioCR:

$$CR = \frac{CI}{RI}$$

When $CR < 0.1$, we can consider Comparison Matrix as Acceptable consistency. Therefore, we can get the (Table 6):

judgment matrix eigenvalues (Table 6)

judgment matrix	Weight vector W	Maximum Eigenvalue	CR	RI
A-B	(0.3077，0.2308，0.3077，0.1538)	4	0	0.90

The following conclusion can be drawn through the combined weight value of (table 6):

After the consistency check, we can get the weight of WCI EPI CDI PPI. WCI and EPI are the greatest influence on RWC, CDI is the second and the PPI is the smallest.

By the above AHP based on the results obtained. In the design of the Intervention plan, we can focus on WCI, EPI, CDI without PPI. From the task 1, having many factors to effect WCI, EPI and CDI, such as Water resources development and utilization rate, comprehensive standard rate of water quality, standard treatment rate of domestic sewage, industrial water quota, agricultural water quota, super groundwater resources collection rate and so on.

So, we use AHP model to set up an Intervention plan to ease the water scarcity, eg:

From the environment WCI considerations:

- There are many ways to increase water resource, such as afforestation, water conservation, rational development of groundwater, the construction of reservoir water, open channel water diversion, the implementation of inter basin water transfer, sea water desalination, artificial precipitation and so on.

From the economy EPI considerations

- Study on urban sewage treatment technology, as a resource, and then use it. Put forward a set of reasonable, economic and efficient process to deal with wastewater.
- Through the high importance of water saving work, increase investment in scientific research funds, control the scale of water to improve the efficiency of industrial water and agricultural water use[15].
- In order to alleviate the tension of water resources and increase the available water in the area, we should pay more attention to the reuse of sewage, waste water and so on.

From the coordinated index CDI considerations:

- Improve the water resources and ecological, economic, social three aspects of coordination. In the rapid economic development and at the same time also have to consider the efficient utilization of water resources, so that it can maintain the coordination of water resources and the ability.

5.4.2 The influence of Intervention Plan and Its Strengths and Weaknesses

Through the AHP, we can get the carrying capacity of water resources index and the economic pressure index have the greatest impact on the RWC[1], the coordination index is the second, the population pressure index is the smallest. In the simulation and support of the data, we designed the Intervention plan can effectively alleviate the problem of water shortage, greatly reducing the RWC value. This shows that although the water resources carrying capacity is still relatively high, but compared to the lack of Intervention plan, the degree of lack of water resources has decreased significantly.

The advantages of water resources Intervention plan:

- It can make people more attention to the problem of water resources around the region.
- To achieve rationalization in the utilization of water resources between countries or regions, especially through the use of water resources planning, driven by the balance of

water supply and demand in the surrounding areas, and use the rational way to promote the people to consider the recycling of water resources[13].

- Increase the urban sewage treatment technology in various countries or regions, the urban sewage treatment as a resource to be used.

The disadvantages of water resources Intervention plan[7]:

- Some relatively backward countries or regions economy, coupled with the national or regional water resources scarce, itself the environment coordination ability is poor, Intervention plan implementation effect is not significant.
- We can't consider all the possible problems and not test the feasibility of the implementation of the region. To a certain extent, the effectiveness of the Intervention plan was reduced.

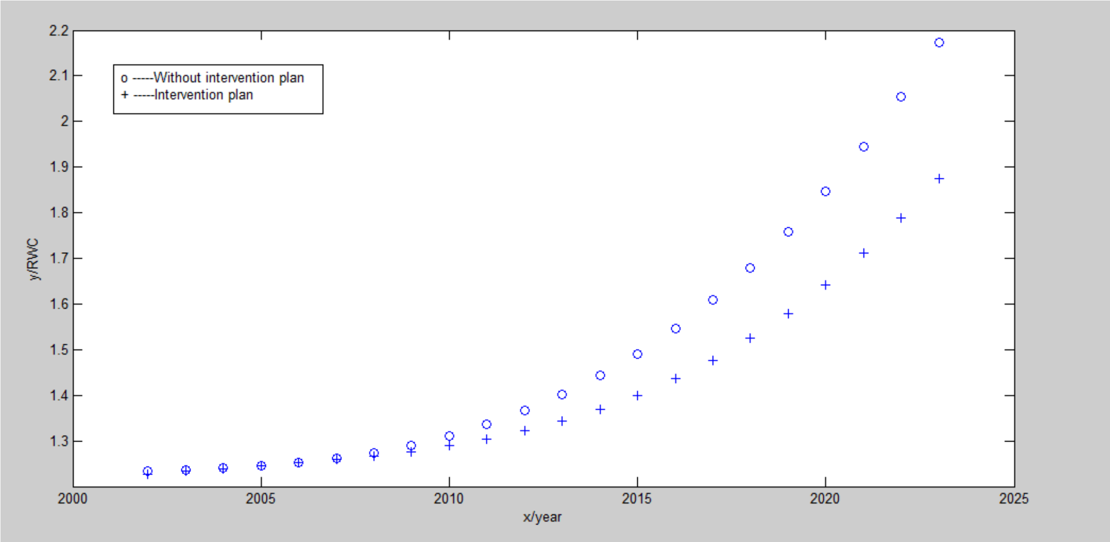
5.5 Intervention combined with model to predict the future water availability plan

The fitting prediction of the task3 can be drawn the RWC curve of change over time without Intervention plan. From task 4 we can get a major impact on the RWC index：the regional water resources in line with the bearing pressure index、the coordinated index and the economic pressure index. We can revolve around these three key factors to develop a plan of our Intervention.

We assume that the policies implemented by the government in 2008 as part of our Intervention plan to test whether our proposed Intervention plan is effective [12]. We make a reasonable evaluation and experiment for various factors affected there as on able evaluation and give the fitting value.

Such as: Guided by the policy of returning farmland to forest, to predict the area of the cultivated land in Hebei province from 2002 to 2008 than previously to reduce 5000 hectares per year on average [1]; According to forecast irrigation quota, 2002-2008 is expected to save each year about 0.03billion [16] cubic meters; Hebei province is a serious lack of resource type water shortage area. Regional water diversion is to increase the bearing capacity of water resources in Hebei province is the most effective method, which expected to add to the amount of water about 0.2billion a year.

We can use the fitting methods of task3 to predict another RWC values change with the passage of time and the curve with the Intervention plan. (figure 5)



RWC curve of change over time（figure 5）

By comparing the two curves, after add the Intervention plan and the curve move to right. We can find that the shortage of water resources a can ease to a certain extent after joining Intervention plan.

Water resources have an important role. It is an important component of the atmosphere, it can regulate the earth's climate, shape the earth's surface form and transport a variety of materials and nutrients, is essential for all biological substances. Now the situation of the water shortage will gradually affect our life. Water problem has become one of the important problems has attracted worldwide attention, it will become a key problem. The UN estimates that by 2025 [16], nearly half of the world population will be living in regions where water shortages. In our forecast of curve can be concluded that the region water shortages have occurred as early as a few years ago. Our Intervention plan can only delay the time of water shortage to a certain extent.

6. Conclusions

By establishing a Comprehensive Evaluation Index System model of Carrying Capacity of Regional Water Resources, Develop a model that provides a measure of the ability of a region to provide clean water to meet the needs of its population. Using the model in the task 1 and China’s Hebei Province to forecast the situation of water resources the next 15 years, and using the AHP model to design an Intervention program of water resources and analysis of the overall impact. Combining the Intervention plan and our model can plan future water resources. Finally, after a series of analysis: We define the Water Resources Carrying Capacity is basically in accordance with the UN water scarcity map, which shows our model is available and Has certain persuasive power. Comprehensive Evaluation Index System Model of Carrying Capacity of Regional Water Resources combines with the Intervention plan, can effectively solve the problem of lack of water resources.

7. Evaluation and Spread of the Model

Strengths

Comprehensive evaluation index system model of carrying capacity of regional water resources [1]: Using RWC as a measure of standards which is affected by CDI, WCI, EPI, PPI. This composite system model has more factors, which can make the data more accurate.

The objectivity of the entropy weight method [14]: Relative to those subjective assignment method, the accuracy is higher and the objectivity is stronger that can better explain the result obtained.

The adaptability of entropy weight method [14]: Can be used for any need to determine the weight of the process, but also can be used in combination with a number of ways to use.
AHP model: This is a systematic analysis method. Method of decision making is simple and practical and the data information can set less.

Weaknesses

Comprehensive evaluation index system model of carrying capacity of regional water resources [1]: Because of the influence of many factors, although the data obtained is more accurate, the calculation is more complex. The model of the standard is calculated through the data analysis, if the data is missing, it can’t accurately reflect the results.

Entropy weight method[14]: Only used in the process of determining the weights, so the use of limited scope, solving the problem of limited.

AHP model: Can’t provide a new scheme for decision making, quantitative data is less, qualitative composition is much. It is not easy to be convinced.

In addition, we can’t find more years of data, which not allows us to get more accurate data fitting.

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9. Appendix

Statistics on water consumption, water supply and forest coverage in Hebei Province in recent 10years:

	资源来源: Source: China Statistics Network										
Year	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004
Total water resources (100 million cubic meters)	27266.9	27957.86	29526.88	23256.7	30906.41	24180.2	27434.3	25255.16	25330.14	28053.1	24129.56
Surface water resources (100 million cubic meters	26263.91	26839.47	28371.35	22213.6	29797.62	23125.21	26377	24242.47	24358.05	26982.37	23126.4
Groundwater resources (cubic meters)	7745.03	8081.11	8416.12	7214.5	8417.05	7267.03	8122	7617.17	7642.91	8091.12	7436.3
Surface water and groundwater resources repetitio	6742.04	6962.75	7260.64	6171.4	7308.25	6212.07	7064.7	6604.49	6670.82	7020.4	6433.1
Per capita water resources quantity (m3 / person)	1998.64	2059.69	2186.05	1730.2	2310.41	1816.18	2071.05	1916.34	1932.09	2151.8	1856.29
The total water supply (cubic meters)	6094.88	6183.45	6141.8	6107.2	6021.99	5965.15	5909.95	5818.67	5794.97	5632.98	5547.8
Total surface water supply (100 million cubic met	4920.46	5007.29	4963.02	4953.3	4881.57	4839.47	4796.42	4723.9	4706.8	4572.19	4504.2
Groundwater water volume (cubic meters)	1116.94	1126.22	1134.22	1109.1	1107.31	1094.52	1084.79	1069.06	1065.52	1038.83	1026.4
Other water supply volume (cubic meters)	57.46	49.94	44.55	44.8	33.12	31.16	28.74	25.7	22.7	21.96	17.2
Total water consumption (100 million cubic meters	6094.86	6183.45	6141.8	6107.2	6021.99	5965.15	5909.95	5818.67	5794.97	5632.98	5547.8
Total agricultural water (100 million cubic meter	3868.98	3921.52	3880.3	3743.6	3689.14	3723.11	3663.46	3599.51	3664.45	3580	3585.7
Total industrial water volume (100 million cubic	1356.1	1406.4	1423.88	1461.8	1447.3	1390.9	1397.08	1403.04	1343.76	1285.2	1228.9
Domestic water volume (cubic meters)	766.58	750.1	728.82	789.9	765.83	748.17	729.25	710.39	693.76	675.1	651.2
Total ecological water (100 million cubic meters)	103.2	105.38	108.77	111.9	119.77	102.96	120.16	105.73	93	92.68	82
Per capita water consumption (m3 / person)	446.75	455.54	454.71	454.4	450.17	448.04	446.15	441.52	442.02	432.07	428
Land area (hectares)	31259	31259	31259	31259	31259	31259	28492.56	28492.56	28492.56	28492.56	28492.56
Forest area (hectares)	20768.73	20769	20769	20768.73	20769	20769	19545	17491	17490.92	17490.92	17490.92
Plantation area (hectares)	6933.38	6933.38	6933.38	6933.38	6933.38	6933.38	5364.99	5364.99	5364.99	5364.99	5364.99
Forest coverage rate (%)	21.6	21.6	21.6	21.6	21.6	21.6	20.4	18.2	18.2	18.2	18.2
Total stumpage volume (billion cubic meters)	164.33	164.33	164.33	164.33	164.33	164.33	136.18	136.18	136.18	136.18	136.18
Forest stock volume (100 million cubic meters)	151.37	151.37	151.37	151.37	151.37	151.37	124.56	124.56	124.56	124.56	124.56

MATLAB program:

```
x=[2002,2003,2004,2005,2006,2007,2008];
    y=[1.233,1.242,1.237,1.243,1.255,1.262,1.274];
    x1=2002:2023
    p=polyfit(x,y,3)
    y1=polyval(p,x1);
    plot(x1,y1,'o')
    hold on
    y2=[1.226,1.234,1.237,1.248,1.251,1.258,1.267];
    p2=polyfit(x,y2,3)
    y3=polyval(p2,x1);
    plot(x1,y3,'+')
```